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ICHTHYOLOGY.—*Salmon psychology.*[1] Henry B. Ward, University of Illinois. (Communicated by Charles E. Chambliss.)

Many years ago I became interested in the salmon and its remarkable life history. Good fortune brought me in personal contact with that great student of American fishes, David Starr Jordan, whose work on the Pacific salmon is well known. His discussions further stimulated my interest and I was able to enter on a series of field studies which has extended over more than 25 years. This work has been intensive rather than extensive and has taken a different direction from that of most of those who have been active in this field hitherto. From the start it has been rather strictly limited in that it was confined primarily to a single species of Pacific salmon, the sockeye or red salmon (*Oncorhynchus nerka*), and to that part of its life cycle spent in fresh water. I have been able to carry on this study at several widely separated places and incidentally to accumulate also scattered information concerning related species and genera which has afforded a valuable check on my own more extended observations of the red salmon.

Desiring to secure the most intimate contact possible with the species, I have spent the summer months following the adults from river mouth to spawning ground, endeavoring to determine just what they did and why under varying conditions of stream, climate, and weather. The tales and interpretations of tourists, natives, fishermen, and Indians were welcomed and subjected to impartial scrutiny in the task of sifting some truth from the mass of error and fancy that always pervades popular accounts of animal life. This combination of personal observations with explanations of others has in the course of time given an intimate knowledge of the fish in its environment sufficient to justify calling this address a study of salmon psychology. It is presented with full recognition of its incompleteness and imperfections, as a basis for directing attention to a somewhat neglected aspect of the study of the salmon.

[1] Address delivered before the Washington Academy of Sciences, December 17, 1936. Received November 29, 1938.

Extensive studies on various types of animals have shown the existence of internal or functional influences and also of external or environmental influences as controlling or directing factors in animal activities. Internal influences are undoubtedly as real and as powerful in fish as in other types of animal life. They are however not discussed here. The purpose of my early studies has been to ascertain how far and in what way the activities of the Pacific salmon in fresh water are determined or modified by external factors. To do this it was necessary to collect by careful and extended study a considerable volume of facts and then to seek to correlate those facts with environmental conditions and the life of the fish. It seems probable that some internal or functional urge impels the adult salmon to start on its migration to the distant spawning grounds, but its exact course will be determined by series of environmental influences which at successive points condition its movements and thus determine its path. Unfortunately past observations on the fish have often been discontinuous or unrelated, and interpretations too largely anthropocentric.

The interpretation of animal activities from the standpoint of human procedure leads into serious misunderstandings. These are most apparent as one departs widely from those types of animal life which most clearly resemble man in structure and development. Nowhere is the error more frequent and more serious than in the treatment of the activities of fish. Even at the first laboratory studies on the structure of fish every student is confronted with the special development of the central nervous machinery, with the absence of the cerebrum, or fore brain, and the magnitude of the olfactory lobes. The student is impressed by the radical difference between the set-up of this system and that of man and the higher vertebrates. From it one may rightly infer that these differences indicate a basis for behavior of significantly different type. A correct knowledge of their habits also and of the underlying basis for their action in particular cases is of primary importance not only in seeking to explain the biological problems in the life history but equally in determining laws for the protection of the fish and proper methods of fish culture to increase numbers and provide against an excessive draft on the fish population in man's search for sport and food.

The study of responses to external stimuli must be made with definite precautions always in mind. First the environment is complex and one may find on analysis that the observed reaction may be due to any one of several stimuli. By extended observation or by experiment these stimuli may be separated or their particular influence be measured. Second, different species or varieties of animals even though closely related act differently under some apparently identical conditions. Accordingly the first step towards the solution of the problem must be taken along the path of determining how one sort of salmon reacts under given conditions. It is not difficult to see in certain cases how confusion has arisen because of failure to observe these precautions.

In the interpretation of salmon activities, a multitude of influences may appear in a particular choice. One must not expect to find a single factor determining what may appear to be superficially a single choice, and the determination of the route chosen by a salmon may depend at one point upon one and at a second place upon another environmental condition. In general, the salmon running in a given stream and at a set time all make the same choice, following a route in the river system often apparently erratic and without evident reason for the preferences shown. However, the path taken by a salmon run is consistently uniform year after year and spawning grounds in a given river system are limited in number and location.

The number of elements which might possibly be involved in the choice of the route is large enough to make the basis for the series of choices difficult to determine, and some earlier observers have felt themselves forced to adopt a mystical explanation. However difficult it may be to solve the problem, the scientist is not justified in accepting this solution. All the experiments with these fish under controlled conditions and all observations of fish in nature show a definiteness of choice which may reasonably be considered to have a factual basis. The problem of the student is to determine this basis in individual cases and by extended observations to ascertain how widely similar conditions determine the same reaction.

The salmon ranks rightly as the most famous of all fish. Its life story manifests a complexity by virtue of its migration from the sea, which is the home in the active growing life period, to fresh water for the discharge of its reproductive functions. Some confusion has been introduced into the story of the salmon as told by different narrators through the combination of features from the life histories of different species of this fish. In this address attention will be directed chiefly to a single species of Pacific salmon, the sockeye or red salmon, in the effort to analyze and determine accurately the response of that fish to the stimuli acting upon it in the changing environments encountered. The life in the ocean is for the most part unknown. The full grown fish appear regularly at the surface of the sea near some river mouth at a given season, enter fresh water streams, ascend to spawning grounds in the higher reaches, and, after discharging this function, all die. The eggs spend a winter in the gravel and the young which hatch in the spring descend gradually to the sea and there disappear, to return after a period as full-grown adults. The young sockeye does not start its journey down stream usually until the second or rarely the third spring.

Following the activities of an adult salmon in this migratory period of existence, one notes first that from the moment of entering the stream it is consistently fighting the current, always moving upward toward its goal. This response to the current stimulus contrasts positively with that of the young on the way to the sea; not swimming actively but drifting, feeding and playing, they float somewhat leisurely down the stream to salt water. While most young salmon start promptly down stream, the sockeye regularly does delay one year or more in a lake.

The adult salmon insistently pursue their course upstream, striving at rapids and falls to surmount these difficulties, and, despite unsuccessful attempts, persist in their efforts until they make their way into the higher levels or are exhausted and die. The erection of a barrier across the stream holds them at such a point, striving day and night to find a way upstream, but never turning back to seek a pathway in some other waters. When exhausted in their efforts to pass the barrier, they may drop back into a quiet, deep pool to rest before renewing their efforts. This may carry them back some distance, perhaps past a fork in the stream. Foerster records that on the Vedder River sockeye once started up the wrong stream at the fork when returning from such a rest. However, they proceeded only a short distance and finally returned to the fork whereupon they turned into the right branch, ascending to the barrier and resumed their efforts to find a way past it.

Incidentally, observations on salmon at barriers and in their efforts to ascend rapids or jump the falls, demonstrate very clearly that their course is not determined by sight, but by definite response to the movements of the water. They may even, when caught in a whirlpool, jump directly away from the fall. They may attempt to surmount the obstacle at some point where no passage is available, but by persistent effort or delaying at times for changes of water level, they succeed at places where, to the observer, success appears impossible on account of the height of the fall or the scanty flow of the stream.

On only one occasion have I seen sockeye during an upstream migration turn about and definitely swim down stream. In this instance closing the gates at a dam higher up on the stream brought about a sudden drop in water level. Then the salmon caught in a rapids became visibly alarmed by the change in water level, turned about and darted down stream until they reached a deep pool. Once in deeper water their excitement subsided; they began to mill around and when an adequate current was found started once more on the upstream journey.

When a stream is swollen to an unusual extent the movement of an upstream migration may be temporarily suspended. Thus extreme fluctuations of water level either up or down, modify mechanically the response to the current stimulus but even before the normal water level is fully restored the adult salmon start again the active dash upstream.

When the current proves too powerful to be conquered, the salmon do not go back to try another tributary and seek a new spawning ground or find an easier approach to the headwaters. They fight the stream until they perish and the run is destroyed. This was the story of the sockeye at Hell's Gate on the Fraser River.

If by drought or some human interference the river flow is cut off, they linger in pools waiting for the water to come again. If it does, they start up once more. If it does not, they perish from disease. But they never turn back!

As the adult sockeye, struggling vigorously and constantly against the current, swims up stream toward some spawning grounds, its route is so definitely limited that it has only two occasions for exercising a choice that will determine its pathway and its ultimate destination. First, whenever it reaches a junction, it might follow either water route offered. Second, it must sometime bring its journey to an end and choose a spawning ground.

The pattern of a stream system is complex, even though it be only a system of moderate size like that of the Skagit River in the State of Washington. Of the numerous possible tributaries into which the sockeye might conceivably go and of the many lakes and spawning grounds which might be selected, only a very few are actually visited. Furthermore the selection is the same year after year, which some observers have explained on the ground of an instinct; let us consider briefly the result of studies at such stream junctions. Earlier investigators spent some time in testing physical conditions at many junctions. They found that the sockeye did not choose consistently the larger stream, the more rapid current, the clearer water, or the reverse. In other words the choice was not determined by volume, velocity, turbidity or any other physical factor which they observed.

After having repeated these older observations without securing any different results, I noticed that in the earlier records statements regarding temperatures were vague, being entered in the record as "water warmer," or even only "warmer." Previous studies on fresh water bodies had involved careful serial observations on temperature and I was aware of the frequent contrast between conditions in air and in water. I began to take temperature records of lakes and stream during the sockeye migrations. Records were made of frequent observations at stream junctions and in spawning areas. Data were secured under all conditions of season, sunshine, wind, light, cloud, stream velocity and volume, melting snow and ice, and other factors that might possibly determine locally in any degree the relative condition of the aquatic environment during, before and after the sockeye run in certain streams.

Before proceeding to discuss examples of temperature influence, let me emphasize the fact that temperature limits are not absolute, nor can they be expressed in figures. There is nothing mathematical in the situation. It is however a very genuine relation. As in many other animals the sockeye recognizes a preferred zone of temperature and doubtless senses optimum, maximum and minimum levels although studies have not progressed far enough to assign even general numerical values to these levels. Furthermore the sockeye in one river do not react favorably to the same temperatures as those which are found in some other river. In general the sockeye in Alaskan rivers are acclimatized to a set of lower temperature levels than those in a Washington State river. Too few rivers have been studied to establish the conditions in many salmon streams or to justify attempts at generalization. Only brief reference can be made here to instances which with others are fully discussed elsewhere.

My own observations have shown definitely that in a considerable series of cases where the branches of a stream differ in water temperature, the salmon universally chooses the one which has the lower temperature. This is in keeping with a long accepted general belief that not only the salmon, but other fish belonging to the same family, are fond of the colder waters. In some cases the migrating salmon show equal definiteness of choice at junctions where no appreciable or constant difference in the temperature of the two streams could be demonstrated. Such a choice is evidently conditioned by some yet undetermined factor. Thus far no instance has been found in which the migrating salmon at a stream junction have chosen the branch exhibiting at the time of choice a higher temperature than the branch which was not followed; but this statement itself is conditioned by another factor, namely, the quality of the water in question.

Migrating salmon have been observed to pass by without hesitation a tributary, branch, or side stream in which the character of the water was well indicated by its name of Sulphur Creek. A change in the course of the headwaters of Sulphur Creek which eliminated the objectionable feature and left the water clear and cold resulted in diverting salmon from the ancient course into the modified waters of this creek, as it was now pure and lower in temperature than the stream the salmon left. Undoubtedly, other factors than water quality do determine the precise choice of migrating fish at stream intersections.

The second opportunity for choice in the fresh water life of the salmon is afforded at the end of this journey upstream. For the sockeye this upstream journey usually stops in a lake in or near which are the spawning grounds. In the deeper water of the lake they rest, it may be for some weeks, until they are ripe and the time for spawning is reached. To reach this point the sockeye sometimes without stopping pass through a lake in the course of the stream. I have not been able to study conditions in such lakes. The lake in which they finally come to rest offers cool deep water as a resting place during the ripening of the fish. When the sex cells are close to maturity the fish rise out of the deep water and find gravel beds for spawning. These are at points along the lake shore, in the inflowing stream just above the lake or in the outflowing stream near the outlet. Here, again, it is sometimes evident at least, that a selection is made of areas in which the seepage of ground water or the inflow from a colder tributary affords an attractive temperature and at the same time the type of gravel bottom selected for the nest of the fish. In northern latitudes this is an interesting and important choice, since by it the salmon nests are made in seepage waters which do not entirely freeze during the winter, but are kept open by the flow of the ground water. When the fish restrained by an artificial barrier in the stream are prevented from reaching spawning grounds and forced through advancing ripening to release eggs and milt in unsuitable areas, these consistently perish in the long cold winter of extreme northern locations, but eggs of the same fish, normally deposited in higher reaches of the same stream not less subject to adverse atmospheric conditions, survive and yield a new brood in the spring.

The definiteness with which the salmon responds to the temperature stimulus in finding spawning places is strikingly illustrated in observations I made in Clear Creek, a tributary of the Copper River in Alaska. The fish under observation were red salmon which, as Jordan, Gilbert, and others state of this species, "always spawn in a lake." These observations I have recorded in full in an earlier paper. At the time of my visit salmon were found entering the stream from the Copper River, scooping out nests and spawning along the banks of the creek. Clear Creek does not now have any lake at any place in its course, nor has it any indication of having had a lake at any earlier period. At its junction with the river Clear Creek at the time of my visit was two degrees Fahrenheit lower than the river. The salmon turned into it promptly; the region in which they were spawning was much colder than the stream further up; it was also an area in which a good supply of cold ground water was welling up into the stream through a sand and gravel bottom. No salmon were going upstream beyond this point; neither salmon nor evidence of previous spawning was found beyond that point. The fish fail here to spawn in a lake, the general habit of the species, but they conform definitely in the response to the temperature stimulus given elsewhere.

But other environmental conditions probably aid the salmon in finding its way to the spawning grounds. The sockeye were found to be sensitive in some instances to the quality of the water, as in the case of Sulphur Creek previously mentioned. At another place they refused to enter a trap built of new green boards, though indifferent to a similar adjacent trap of seasoned concrete. Other observations also serve to show the existence of ability to discriminate on the basis of chemical sense (taste, smell).

Sight plays a secondary role, in general, in the activities of fish. The eye is conspicuously rounded and myopic. While this is partial compensation for the density of the medium in which fish live, the eyes are not accurate in interpreting objects. The lures of the fisherman when effectively handled lead the fish to grasp at them or jump for them on the basis of position on the surface, movement, form, or color of a character known in other more desirable objects. The lure creates a transient impression by some feature that produces a particular effect and not by its actual resemblance to the object sought by the fish.

In the choice of the migration route and in the success of the sockeye's journey, sight plays an exceedingly minor part. At a rapids where the salmon seeks by jumping to attain a higher level, it often jumps into a closed pool, onto a bare rock surface, or into a tangle of shore plants from which it may extricate itself by aimless floundering about, or where it may become trapped and perish. It will jump endlessly at a fence erected to barricade the stream or swim back and forth incessantly seeking an opening large enough for its exit when no jump can top the fence and no search can find an opening.

The migration route cannot even be generally directed by memory or persistence of past images. To be sure in many cases, perhaps in most, the adult fish ascends the same stream which in early life it descended to the sea. But as already noted the young fish going downstream plays along near the shore; the adult swims strenuously in deeper water on its way up the same river. The two pathways are separated by a distance greater than the range of sight. Even if floods have not intervened and produced radical alterations, the river channel and banks have changed every season and with that all the features with which the young fish had come in contact. Whatever aids sense perception gives in determining the way upstream, they are not furnished by the organs of sight.

The influence of light on migration movements of the sockeye is important to consider. In my observations the adults were not found to continue the upstream migration during hours of complete darkness but to rest in deeper holes or in eddies. With the coming of dawn they began to move upstream and in a brief time were vigorously combatting the current and jumping at falls. Later in the morning this activity diminished and ceased on sunlit days, though in cloudy weather it was manifested intermittently during the midday hours. As the sun declined the sockeye again became active and continued through the twilight hours. The period of activity seemed to be limited to the time of diffused illumination and to terminate when the direct rays of the sun were no longer totally reflected from the surface of the water. When in the late afternoon conditions were changed again, then the fish were once more active until the twilight period came to an end.

Some situations are difficult to analyze. Thus, the effect of a heavy rain is seen clearly and very promptly and has been witnessed and recorded by many observers, both on the Atlantic and on the Pacific coast. During a spell of dry weather, which usually is also warm weather, salmon which are at the mouth of a river or have started up, loiter about in deeper pools and appear to have lost the desire to fight the stream. Even a moderate rise in the stream as the result of rain promptly arouses the activity of the fish and they shoot ahead vigorously. Here the stimulation may be due to volume, temperature, or quality of the water. The first-named cause seems least likely because salmon in nature frequently leave a stream of large volume to continue the migration in one much smaller. But salmon like cooler waters such as one finds in streams after a rainstorm; then also they have fresher waters and changed relations of O_2 and CO_2 tension. This situation is only apparently modified in Alaska where warm sunny weather means rapid melting of ice and snow on nearby mountains. Thereupon the streams carry promptly a daily flood of cold water and the sockeye go up eagerly. This evidences that they also are keen at this period of life to follow the taste of fresh river water. Perhaps both stimuli here favor rapid action. In the complex environment of nature many other factors still remain to be investigated before it is possible to complete the list of the responses which the adult salmon makes to the conditions met during the migration to the spawning grounds.

Concerning the young salmon on its way to the sea, little need be said. There is no choice except to go or not to go, and the movements of the young fish in the downstream direction are slow and apparently hesitating. Young sockeye do not leave the lake in or near which they were hatched until the second spring or even later. As they proceed downstream they feed and play in the small eddies along the shore, dropping occasionally from one level to another as if disinclined to make the venture. But they go over the spillway of a dam involving a descent of 240 feet in just the same way that they drop down a 6-inch step in the rapids. Their vacillating movements contrast sharply with the vigorous striving of the adult to make the ascent of the river. In lakes or reservoirs met on the journey the young keep near the shore; when affected by rising temperature of surface waters they descend into deeper water to find a cooler environment and become trapped by the surface stratum of warmer water which blankets the lake and cuts off access to the outflowing stream. Here in the lake or reservoir they remain "land-locked," cut off from further downstream migration since that can only be carried out if they desert the cool, deeper water levels to enter a warmer current. And that they will not do. So here again is seen the response of the salmon to a temperature stimulus. Those young sockeye which find their way open and reach the sea, disappear in the deeper waters, and thereby pass out of the freshwater region to which this account was to be limited.

These observations show only imperfectly the influences which direct the migration of the adult salmon in the period of its freshwater existence. Further determination of factors or of the extent to which those illustrated are operative, must await further studies, but from these one may conclude that at least one current belief is not tenable. The fisherman stoutly avers that the adult salmon returns to the very gravels in which it was spawned and hatched, and this view, designated as the "parent stream theory," is widely held by others. But after all, this is no explanation in any sense; it is at most only a convenient expression to conceal lack of knowledge concerning the real situation. At best it assumes the inheritance of a vague, indeterminable influence which does just the right thing at just the correct time to enable the young salmon to find their way from the river mouth to some suitable feeding grounds in the ocean and when the time of maturity is near at hand to retrace their steps to a place known to be fitting for spawning because these particular fish were spawned and started life at that point. A view so indefinite, so loaded with assumptions and so mystical in character, can hardly serve the purposes of scientific investigation however convenient and appealing it may be.

Some of the difficulties in accepting this view deserve at least brief mention here. The correctness of the assumption that the salmon return to a parent stream is at least still open to question. Time does not permit an extended discussion here of the proofs thus far offered. It is my intention to present at a later date a fuller analysis of the various observations and experiments which have been put on record. In my opinion they are not conclusive. While they show that some salmon do conform to the assumption, it is equally certain I think, that all do not. The positive evidence secured has been unduly emphasized and the defects in the proof overlooked. The number of salmon that have been marked or tagged in numerous experiments is very large; the percentage of such that have been recaptured is too small to justify the claim that the record is "conclusive evidence." Let me illustrate what I mean.

A serious-minded student stands at the entrance of a great industrial plant and watches 10,000 employees pour out and swarm down the road which leads to the city. By skill he marks 500 of these and his assistant located at the entrance to an amusement resort on the other side of the metropolis recognizes 10 of the marked men and women entering the resort some hours later. He thinks there were more who passed unnoticed in the crush at the gates he was watching. No one else has noticed any of the marked workers going anywhere else. What conclusion may be reached properly from such data? In their major factors the two cases are strikingly similar and also equally alike in proving nothing about the habits of fish or men. The same misuse of results from a type of random sampling led a prominent news service into ludicrous and serious error in a political campaign not many years ago.

Apparently no one has yet given attention to the non-conforming element. It is hardly satisfactory to dismiss the case with the statement that sometimes an erratic or abnormal salmon may turn up in the wrong place. The number of such strays is too large to be thus summarily discarded and given no further consideration. Certainly an answer must be sought to some questions which suggest themselves. How large is the part which does not return? Where does this fraction go? What influences that fraction, be it large or small, to go to a new spawning ground and do violence to the inborn, mystical compulsion which the parent stream theory assumes? These questions are difficult to answer. I have felt that some light might be thrown upon the situation by study of the fish in a simple environment, and that is during the part of the life cycle spent in fresh water.

From evidence already published and also outlined in this paper, I feel that there is more reason to believe that in its progress upstream the adult follows a highway through the waters which is marked out from point to point by signs as definite as those which determine for us our course along a road. The highway signs that mark the way through the waters are indicated by temperature, quality of the water, or other physical and chemical features that yield responses as definite as those which we find the fish manifesting under controlled conditions in experimental tanks. The stream which the salmon ascends is not necessarily a home stream, nor is the course of the fish determined by previous knowledge of these waters. The adult seeking the spawning grounds goes upward by constraint along a fixed route and the young wander downstream following necessarily the same course to reach inevitably the waters of the ocean, in which they find conditions for life and growth to maturity.

No assumed mystical impulse makes them go back to a specific place because of their relation to that at the start of their existence. They do, perhaps usually, return to that place because like their ancestors they react in a specific way to the stimuli they encounter on the journey. But they do this only so long as the conditions they meet on the journey remain unchanged. To characterize the situation as due to a parent stream theory is to adopt an empyrical conclusion with all the errors and limitations of empyrical findings. It is to abandon the search for a scientific basis and to lose the greater power over changing conditions which knowledge of controlling influences will give. If the salmon have been shifted to a new environment or if by any disturbing influences the environmental conditions of the old route have been changed, they go to some other place, a new goal determined by the newly created conditions which they meet. To those new conditions they react in the manner determined by their nerve pattern and not by the ancestral relation to any geographic locality.

No one should lose sight of the fact that even in our rivers and on our coasts natural conditions are changing and these changes give opportunity for distribution of a species into new areas as well as for the origin of possible new species. Some efforts have been made already to explain on such a basis the origin of the Pacific salmon and their wide distribution along the coastal areas of the northern Pacific. A recent species, geologically speaking, its origin may be associated with the period of continental glaciation when it spawned along the shore at the foot of the glaciers. As these ice fields slowly receded it followed up the resulting water courses to find its spawning grounds near the source of the stimulating cold freshwater run-off from the glaciers.

Different species of Pacific salmon do not respond in the same manner to the same stimuli. One conspicuous instance of this has been mentioned: the sockeye young usually tarry over one winter in a lake. Other species of Pacific salmon go more or less promptly down the river from the place they were hatched into salt water and disappear. In variable periods the different species reappear as full grown fish and start upon the freshwater period of their existence. It would be interesting to follow the precise story of these other species of Pacific and Atlantic salmon on the coasts and in the streams of North America. Accounts by older and more recent students of the problem give many details of these stories. The accounts manifest general similarity though differing in details just as the structure of all these forms exhibits a general likeness despite the particular differences also recorded. In both series are to be found evidences of the past that deserve closer attention.

Finally, to make the story complete, the record of the sockeye's life in the ocean must be studied from the same point of view as that taken in the account of its freshwater existence which has just been reviewed. One can hardly doubt that similar environmental stimuli affect it; namely, current, temperature, quality of water, etc. But how does it react? Where do these controlling influences lead it and what brings it, after a period of active growth, back to the shore?

What leads it to enter some river and seek a spawning ground? Surely, not a blind instinct or some inscrutable impulse. In the sea environmental conditions are more variable and change violently and suddenly. Periodically storms modify currents; schools of fish are broken up and scattered widely. Even under generally favorable conditions only 20 or rarely 40% of tagged fish have made the short journey to the places where keen-eyed watchers were waiting for them. Why did this marvelous instinct fail them? Is it not more reasonable to suppose that in shifting waters some were brought into new environmental conditions. In these they responded naturally to the same stimuli that had led their ancestors for unnumbered generations. But those stimuli under the changed conditions lead them to a new goal. Complex as the ocean is, one finds there the same environmental stimuli, mechanical, physical, or chemical, that are in fresh water, and these guide the salmon to some suitable stream for the last phase in its life cycle.

The address was illustrated by a series of lantern slides and figures made from photographs of conditions in nature taken in the course of studies in the field, and by maps of the regions covered. Some further detailed explanations were presented in connection with slides and maps as shown.

PALEONTOLOGY.—*A fossil catfish* (Felichthys stauroforus) *from the Maryland Miocene.*[1] W. GARDNER LYNN and A. M. MELLAND, Johns Hopkins University. (Communicated by C. LEWIS GAZIN.)

A well-preserved skull taken from Zone 12 of the Calvert Formation of the Miocene about three miles south of Plum Point, Maryland, proves to be that of a marine catfish congeneric with the Recent gaff-topsail fish, *Felichthys felis.* This specimen provides the first record of a siluroid from these deposits and indeed appears to be the only complete skull of a fossil marine catfish yet known from North America.

The catfishes (Order Nematognathi) fall into some twenty-five families, most of the members of which inhabit freshwater streams and lakes. However, one large family, the Ariidae, contains about forty-five estuarine and marine genera, which are widely distributed in tropical and sub-tropical regions. The Nematognathi are represented but scantily in fossil records for, although a considerable number of fossil species have been described, the remains upon which most of them are based are too fragmentary to permit of any accurate de-

[1] Received November 18. 1938.